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## 2D structure of nitrogen molecular bands radiation of microdischarges in DBD in $N_2$ - $O_2$ mixtures: Experimental results

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*Results of spatio-temporally resolved optical emission spectroscopy of single filaments in a dielectric barrier discharge in nitrogen containing 3% of oxygen are presented. Results of numerical modelling are discussed, too.*

### 1. Introduction

Dielectric barrier discharges (DBD) are known to consist of many filaments or microdischarges (MDs). Due to their small dimensions (typically mm) and short duration (in the nanosecond-range) there is a lack of experimental data seizing their two-dimensional propagation. This contribution reports about our first attempts of the investigation of MD development in axial and radial direction.

### 2. Experimental technique

The discharge cell consists of two semi-spherical electrodes, both covered by glass and mounted with a gap distance of 1.4 mm (see figure 1).

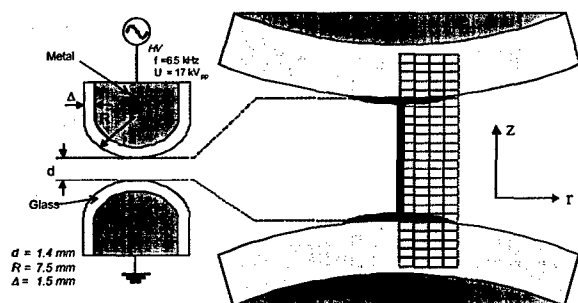


Figure 1: Electrodes and schematic drawing of the spatial scanning

The DBD was generated in a flowing gas-mixture of nitrogen with 3% admixture of oxygen. At these conditions the microdischarges have a good reproducibility in electrical characteristics and position [3]. Using a lens, the discharge area was imaged to an optical slit, adjustable and movable in vertical as well as in horizontal direction. For vertical motion of the slit a stepper motor, for horizontal movement a micro-controller was used. By changing the horizontal slit position the single filaments can be scanned along the discharge axis  $z$  (resolution  $\Delta z = 0.1\text{mm}$ ) for a chosen radial discharge area (resolution  $\Delta r = 0.2\text{mm}$ ). The technique of Cross-correlation spectroscopy (CCS) allows a time resolution of about 0.1 ns. A detailed description of the experimental set-up and the CCS-method is given in [2].

### 3. Experimental results and discussion

The emission spectrum of a filamentary BD in the mixture ( $N_2 + 3\% O_2$ ) mainly consists of the 2<sup>nd</sup> positive system of nitrogen (SPS) and the 1<sup>st</sup> negative system of  $N_2$ . In figure 2 for the 0-0 transition of the SPS at  $\lambda = 337.1\text{nm}$  spatio-temporally resolved intensity distributions are shown for two different radial positions. The intensity is coded in grey-scale in logarithmic steps.

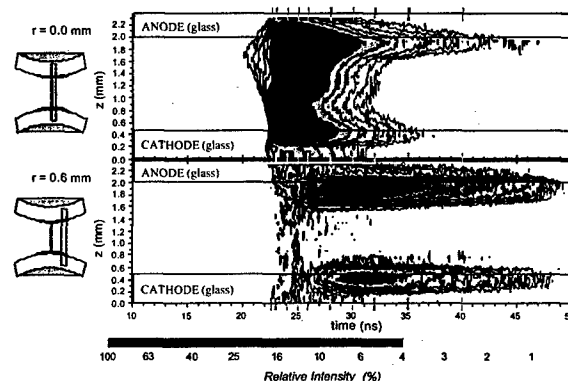


Figure 2: Spatio-temporally resolved intensity distributions for different radial positions - top: centre; bottom: outside

In the picture for the centre (top) a cathode-directed ionizing wave and an anode glow is seen. These phenomena have been discussed in detail elsewhere [2]. For the fastest outside position investigated in the experiments ( $r = 0.6\text{mm}$ , bottom) radiation is only seen on the dielectric surfaces. From the comparison of the two pictures one can already suggest, that at the surfaces the discharge spreads radially.

To resolve the radial structure of MD in the volume the radial resolution of  $\Delta r = 0.2\text{mm}$  is too low. It is known, that the radius of a MD does not exceed 0.4mm [4, 5]. The 2D structure of MD propagation is summarized in figure 3 at different times. The stage of the cathode directed ionizing wave is discussed in attention to numerical modelling presented in [6]. Short after its arrival at the cathode (approx.  $t = 24\text{ ns}$  in time-scale used here, but  $t = 32.0\text{ ns}$  in [6]) the radiation radius along the gap in direction from the anode to the cathode decreases. Numerical modelling in [7] has demonstrated that the decrease of the radiation radius is not characteristic for a streamer. One possible reason of this

difference given in [6] is the effect of a preliminary electron background to MD propagation.

Another possible explanation is a small horizontal jitter of the MD position during the measurements.

The discharge processes on the dielectric surfaces shows a outward directed propagation at both electrodes. Due to an electron accumulation at the microdischarge tip on the anodic dielectric a radial component of the electric field  $E$  is formed. Therefore after the formation of the cathode-directed luminosity wave and the anode glow the MD spreads at the dielectrics (see in fig. 3 for  $t \geq 28$ ns), forming a funnel-shaped MD-foot [2]. The electron accumulation leads to a decrease of the local electric field in the discharge centre, but not yet in the surrounding area. So in the MD-centre the signal decreases and the maximum of the signal propagates outwards (beginning from  $t = 28$ ns). In the following the negative surface charge grows radially and the signal continues to move to the outside with decreasing intensity and a velocity of about 0.1 mm/ns. Similar, on the cathodic dielectric a positive surface charge -responsible for the observed Lichtenberg-figures [2]- is spreading with decreasing value and the discharge creeps over the dielectric surface. An influence of the semi-spherical electrode geometry can be seen by the slight move of the outside spreading maximum in vertical direction (see fig 3). The surface discharge phenomena are not included in the numerical model presented in [6].

#### 4. Conclusions

The evolution of a microdischarge in nitrogen-oxygen mixture was measured by Cross-correlation spectroscopy in axial and radial direction. The results visualise the discharge propagation. In the volume even before the cathode directed ionising wave arrives the electrode a decreasing of the radiation channel towards the cathode is observed. The microdischarge dynamics on the dielectric surfaces is characterised by an outward creeping radiation maximum. These observation confirms with previous experimental and numerical modelling results [2] and can be explained by the dynamics of surface charging processes.

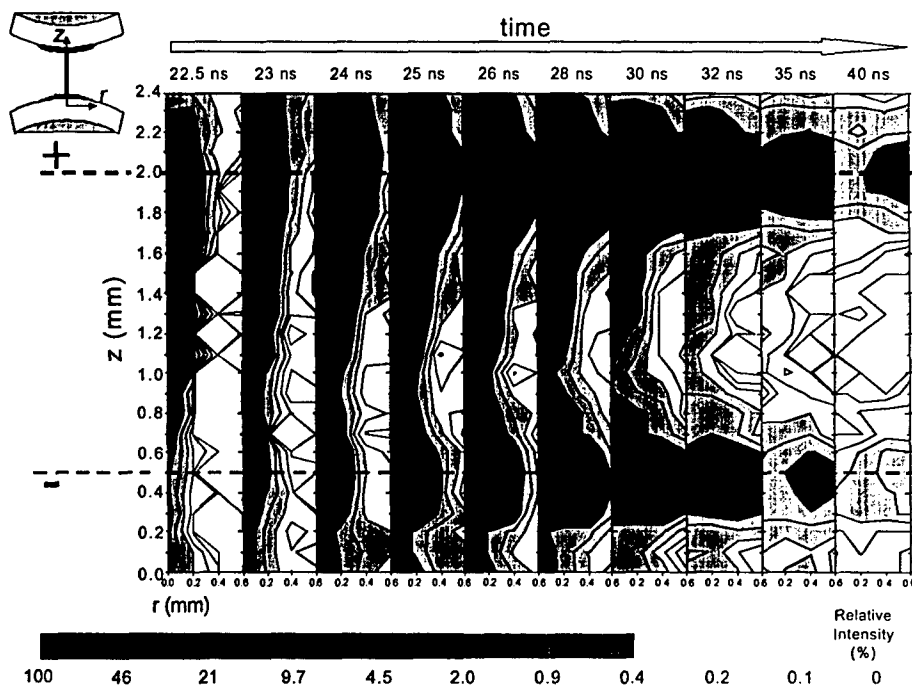


Figure 3: Spatial structure of the microdischarge evolution (radial co-ordinate  $r$  always at position 0; 0.2; 0.4 and 0.6mm for every time step  $t$ ; at  $t = 22.5$ ns the cathode directed wave has nearly arrived at the cathode)

#### 5. Acknowledgements

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#### 6. References

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